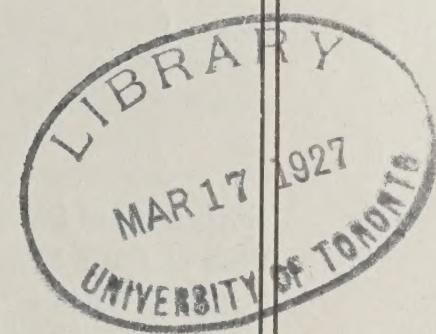


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# PRODUCING CLEAN MILK

By GRANT LOCHHEAD, PH.D.



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industry is intimately bound up with the  
sanitary quality of the milk produced on  
our farms*

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# PRODUCING CLEAN MILK

By A. GRANT LOCHHEAD, Ph.D.,  
*Dominion Agricultural Bacteriologist, Dominion Experimental Farms*

## IMPORTANCE OF CLEAN MILK

The welfare of the whole of the dairying industry is intimately bound up with the sanitary quality of the milk produced on our farms. Even more than the average milk producer perhaps realizes, the quality of our Canadian cheese, butter, condensed and powdered milk, ice-cream, as well as of the milk and cream consumed in liquid state, is dependent in no small measure upon the efforts which he as an individual puts forth to produce what is called clean milk. In the last analysis the degree of excellence which these various raw and manufactured products are able to attain will be limited by the degree to which the producer is able to deliver a pure product. The subsequent handling, of course, is likewise of great importance, but no manufacturer, no cheese-maker, no butter-maker, no city dairy can raise the quality of its product higher than the quality of the milk delivered at the receiving vat.

It is gradually being realized that quality in milk depends on something more than the percentage of butter-fat contained, but in Canada we have still far to go in the matter of just remuneration to the producer on the basis of cleanliness. The introduction of the system of payment on the basis of butter-fat content was a proper step, but so far the equally just system of payment according to sanitary quality is not in force to the same extent. Yet in spite of this, the production of clean milk, while entailing more care, is worth while, bringing benefit to the producer as well as to the consumer. A better grade of butter, cheese or milk-powder resulting from a better grade of raw milk will inevitably react to the advantage of the producer. While the gain may seem indirect, yet it is bound to affect the individual sooner or later. Furthermore, improvement in the sanitary quality of a milk supply will directly benefit the producer by reducing the losses due to having milk rejected as sour, tainted, or otherwise unsuitable. If any further incentive to produce clean milk is required, it is only necessary to mention the lessened danger to the health of the producer's family and his stock which undoubtedly follows the adoption of clean, sanitary methods about the farm.

## BASIS OF CLEAN MILK

Milk is properly regarded as one of our most important, if not the most valuable of our articles of food. At the same time it possesses two outstanding disadvantages. It may be, of all our foodstuffs, the most dangerous to health, and on the other hand, by being easily subject to change, is capable of spoiling readily so that not only the milk as such but also products derived from milk are of much inferior quality.

In milk are to be found all the constituents necessary to support life, and in the fresh, clean state it may be said to be the ideal food. Unfortunately, however, other living things besides human beings and calves find cow's milk an ideal food. Bacteria—microbes or germs as they are more popularly called—likewise thrive on milk, and it is due to the presence and growth of these forms of life in milk that this food may become a source of danger to health, or so deteriorate that it becomes useless as such or for further manufacture.

## NATURE OF BACTERIA

Bacteria belong to the smallest forms of plant life, consisting of single microscopic cells so minute that they cannot be seen with the naked eye. They comprise the smallest living things known, and of those occurring in milk the great majority measure approximately  $1/20,000$  to  $1/10,000$  of an inch in length. In the popular mind bacteria are usually associated with disease, but of the many hundreds of different kinds of bacteria known, only a small number are able to cause disease to man or animals. Many other kinds are of distinct value to mankind, such as those growing in the soil, helping to prepare plant-food out of the products of decay. In milk, however, the presence of bacteria is distinctly undesirable, not only as regards those kinds responsible for disease whose presence in any amount is dangerous, but also in the case of the numerous bacteria not associated with disease. These find in milk all the food material necessary for rapid growth, and if allowed to increase unchecked produce changes in the milk resulting either in complete spoilage or lessened value. The rate at which germs already present in milk will increase will depend upon the temperature more than upon anything else. Those most commonly found in milk grow most rapidly at temperatures of  $70^{\circ}$  to  $100^{\circ}$  F. Below  $50^{\circ}$  the growth is much slower while high temperatures are destructive. Practical use is made of this means of killing bacteria, both in pasteurization, whereby the great majority of bacteria are destroyed by a moderate application of heat, and in sterilization, which means rendering completely germ-free. To effect this, higher temperatures are required.

## EFFECT OF BACTERIA IN MILK

Different kinds of bacteria affect milk differently. With some varieties the spoilage is visible to the eye, when the milk curdles or where it undergoes a change of colour. With other types of spoilage there may be no visible change due to bacterial development, the harmful effects being noted in a change of flavour or odour. The most common cause of spoilage is doubtless that due to souring, resulting from a development of acid-producing bacteria, which though harmless to health, yet entail great losses to producers and manufacturers, especially in the fresh-milk trade, in the condensed-milk, and milk-powder industries. Other varieties of germs are able to cause objectionable flavours which may be bitter, metallic, fishy, oily, turnipy, soapy or putrid, according to the dominant type of germs. Naturally even slight development of any of these types tends to lower the quality of the milk and of the butter or cheese. Some bacteria affect the appearance and consistency of the milk, not only by curdling it, but by rendering it slimy, or turning it viscid, giving the so-called "ropy" milk. Occasionally changes in colour result from the action of bacteria capable of turning the milk reddish, bluish, yellowish or greenish, though spoilage of this type is doubtless less commonly encountered.

Although in many instances, bacterial development does not reach to such a point that the milk is obviously spoiled, yet the quality will be impaired in proportion to the growth. It should always be remembered that bacteria are living things and require food. In the course of their growth they must feed on the various ingredients of milk, and while the destruction is greater the greater the number of microbes, yet growth in any amount acts adversely on milk quality, the loss of which can never be remedied.

## MILK AND DISEASE BACTERIA

Bacteria capable of spreading disease should naturally be absent from a clean milk. They are not concerned primarily with milk spoilage and subsequent loss of quality in butter or cheese, but are of the utmost importance in

relation to the health of the consumer. Of the diseases communicated through milk, tuberculosis is by far the most serious, and most of our efforts in connection with the reduction of the spread of infectious diseases through milk have been directed towards the elimination of tuberculosis in our dairy herds. There is now little doubt that tuberculosis in children, and especially in young children for whom milk constitutes the chief article of diet, is due in a large proportion of cases to the consumption of milk from tubercular cows. Not only the consuming public, but also the producer should be vitally interested in the production of a tuberculosis-free milk; not only is there danger to his own family, to calves and hogs consuming tubercular milk, but there is the serious financial loss to be considered through the ravages of this disease among his dairy herd itself.

Other diseases capable of being transmitted through milk are typhoid fever, dysentery, scarlet fever, septic sore throat and infantile diarrhoea. In these cases, however, infection of the milk is caused rather through the handling of the milk or its containers by persons carrying the germs of these diseases. A chance infection, not only by a person evidently diseased, but also by apparently well people carrying the bacteria—so-called carriers—may, through the rapid growth of the germ, cause infection over a wide community.

Clearly then, no milk coming from a diseased cow or carrying disease germs introduced through careless handling can be called "clean".

### PASTEURIZATION AND ITS FUNCTIONS

As safeguard against the spread of disease through milk the process of pasteurization is being more and more widely adopted, especially for the fresh milk and cream trade. Unfortunately there still exists in the mind of many, producers as well as consumers, a certain misconception as to the functions and limitations of pasteurization. Its object, briefly, is to make a good milk a safe milk; it can never hope to turn a bad milk into a good clean milk. Performed properly, pasteurization will kill infectious germs and about ninety-nine per cent of the other bacteria which, though not disease producing, yet affect the quality of the milk. Quality is spoiled, however, not so much by the germs in themselves, but rather by the chemical substances produced through the growth of the germs which affect the flavour, consistency or appearance of the milk. While pasteurization, then, will tend to delay further spoilage and lengthen the keeping quality of bad milk, yet it cannot restore the quality of clean milk which has been lost through bacterial growth previous to pasteurization. Pasteurization can never replace cleanliness in production.

### WHAT IS CLEAN MILK?

If milk could be obtained and stored free from any bacteria whatever it would keep indefinitely. Strictly speaking clean milk should contain neither foreign matter nor any bacteria whatever. As absolutely germ-free milk is not practically possible, it is sufficient to consider clean milk as milk from healthy cows, free from dirt and foreign matter, and containing only a small number of bacteria, none of which are disease-producing.

The presence of the visible dirt which collects on standing or when milk is filtered is often taken as a measure of its cleanliness. Visible dirt undoubtedly indicates gross carelessness in handling and such milk will usually have a very high number of germs. On the other hand, milk may be seriously contaminated with bacteria and yet show no visible dirt. Obviously such a milk can not be called clean. Clean milk, then, should be more than clean to the eye; it must be bacteriologically clean.

## CONTAMINATION OF MILK

From the time it leaves the cow up to the time it is consumed or used in manufacture, milk is constantly subject to bacterial contamination and bacterial growth. Every handling from one container to another, every hour it remains at ordinary temperatures adds to its total germ content. In any given sample of milk, the number of bacteria will depend upon two factors, first, the amount of contamination from outside sources, and second, the extent to which these added bacteria have increased. The production of a bacteriologically clean milk depends therefore upon keeping outside contamination at the lowest amount and upon checking the growth of the germs which have contaminated it. Measures to prevent the increase of germs already in milk are best summed up in one word,—cooling. The present bulletin deals chiefly with the sources of contamination and the means to keep it at a minimum.

### EXPERIMENTS IN CONTAMINATION

To most of our Canadian milk-producers, bacterial contamination of milk is by no means a new term. The importance of excluding germs from milk is frequently and rightly stressed by our agricultural periodicals and in other related literature which reaches the farming community. As a result very few, if any, of our milk-producers to-day are quite unaware of the fact that careless milking methods, exposure of milk to dust, and the introduction of dirt all introduce germs which tend to lower the quality of the milk. At the same time it is plain that a very large portion of the raw milk delivered at our receiving depots is very highly contaminated, and quite unnecessarily so. This was made evident to the writer in the course of a prolonged study of the bacterial content of milk arriving at different receiving stations in the centre of one of our best dairying districts. Time and time again it was seen that while a number of farmers were delivering clean milk of low bacterial content, numerous other patrons of apparently equal intelligence and with equal facilities and equipment were producing highly contaminated milk.

The whole question of prevention of contamination lies, we believe, in a knowledge of the relative importance of the various factors upon which the germ content of the milk as it leaves the stable depends. While the producer may understand in a general way from what sources germs may invade milk, yet if he neglects to pay greatest attention to the main sources, much of his effort to keep the bacterial count low will be of little avail.

With the object of determining more fully the relative extent to which the various sanitary factors in milk production contribute to contamination under conditions of hand milking, an extended investigation was conducted at the Central Experimental Farm. It was aimed to carry out the test under commercial conditions, and study the good or adverse effect on the bacterial content of the milk of methods of procedure applicable to the average dairy farm without employing elaborate methods involving much extra expense. Careful methods were contrasted with careless methods in connection with the care of the stable, of the animals themselves, of the milking utensils and with the methods of milking. Tests were made to note the unfavourable effect upon the germ content of a single unsanitary operation when other methods were "favourable." Moreover, when all-round careless, unsanitary conditions prevailed, the effect of different improvements was compared. In addition, many combinations of conditions were tried out to obtain an idea of the methods of handling in relation to one another as reflected in the bacterial content of the milk. The figures used as illustration represent in all cases averages of a large number of separate tests, the entire experiment occupying five months during which time the individual milk of twelve cows was examined daily.

## CONTAMINATION LARGELY CONTROLLABLE

When careless, unsanitary conditions prevailed throughout, the number of bacteria in the milk averaged 397,600 per cubic centimeter (c.c.).\* On the other hand, when a change was made from a careless to a careful method of handling which involved the exercise of ordinary sanitary precautions without resort to expensive, impracticable means, the average germ content of the milk fell to 3,200 per c.c., or less than one per cent of that present under careless handling. Between these figures came a series of bacterial counts varying with the degree to which sanitary methods were used. The improvement under sanitary conditions was effected, not by the introduction of new equipment, but rather by employing different methods. The point to be emphasized here is that ninety-nine per cent of the contamination of milk is controllable by the producer himself if he will take the trouble to understand what are the chief sources of contamination, and is willing to exercise ordinary sanitary measures which anyone handling a food product should be willing to take. While an absolutely germ-free milk is not possible, a clean milk of low germ content is undoubtedly possible on every dairy farm.

### Two OUTSTANDING SOURCES OF CONTAMINATION

While constant care and vigilance must be maintained on all sides if the cleanest milk is to be obtained, yet the various sources of contamination are of very different relative importance. Two sources stand out pre-eminently in contributing to contamination, namely, imperfectly cleaned utensils and dirt from the cow. In the first instance, contamination is the result of infection by bacteria developing in traces of milk left in uncleansed or improperly cleaned pails, while in the second case it is due to small or large portions of manure and dirt falling directly into the pail during milking.

We should like to simplify, if possible, the whole question of contamination in the mind of the producer; have him worry less about all other sources of contamination, and have him think bacteriologically on these two prime sources; have him consider the millions of bacteria lurking in an unsterilized pail or contained in the fraction of an ounce of manure, and have him concentrate his preventive measures on insuring that the pail and the cow are clean. Then, we believe, troubles arising from unclean milk would be largely solved.

### CONTAMINATION FROM THE Cow's BODY

The cow's body is one of the two most serious sources of bacterial contamination and at the same time the greatest source of visible dirt found in milk. The trouble is caused by particles of manure, hairs, dandruff or other dirt dropping directly into the milk-pail during milking, and the extent to which this can be prevented will be directly dependent upon the care taken to insure that the animals are clean at milking time.

The chief source of infection is due to particles of manure adhering to the coat of the animal becoming detached during the process of milking. Even a small speck of dried manure contains millions of bacteria and these of the most undesirable types, with a capacity for causing spoilage of a most objectionable kind. Consequently the efforts of the clean-milk producer should be largely directed to reducing this infection to a minimum by keeping the body of the cow clean.

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\* One cubic centimeter (c.c.) is equal to approximately one-quarter teaspoonful.



Fig. 1—Producing contaminated milk. One of the main sources of bacteria in milk is dirt dropping directly into the pail from the unbrushed udder and flanks of the cow. Note the uncovered pail which greatly adds to the contamination from this source.



Fig. 2—Producing clean milk. Contamination from the cow's body is reduced to a minimum by keeping the animal clean. Clipping the hair of the udder and flanks of the cow greatly facilitates cleaning. Note also the small-top pail, and the clean suit of the milker. Under such conditions few bacteria can fall into the milking-pail.

The flanks and udder should be brushed off every day and care taken to prevent the cows lying on manure or other dirt. Brushing of the cows is best done about half an hour before milking and reinfection of the animal should be prevented by the regular removal of the manure out of reach of the animal. In this connection the size of the stall is important. Cows are often filthy because the stall is too long, allowing manure to fall inside, contaminating the litter. On the other hand, if the stall is too short, the animal if lying down becomes dirty by touching filth in the gutter or treading in it. Naturally, then, the state of the animal's body will depend not only on the care exercised in brushing it, but also on the care taken in the stable to keep manure and filth away from the animal. While it is desirable from other standpoints to remove manure from the stable entirely, yet as far as actual bacterial contamination is concerned the important thing is to keep it from touching the cow. Half a ton of manure in the corner of the barn may be quite harmless yet a fraction of an ounce falling from the cow's flank into a pail of milk can well spoil the sanitary quality of a day's production.

The following table illustrates that the best way to keep the cow's coat from infecting the milk is to keep manure away from the animal. Daily brushing, under practical conditions, is wasted if manure is not kept away from the animal.

#### METHODS OF PRODUCTION AND THEIR EFFECT ON THE BACTERIA IN THE MILK

	Bacteria in milk, per c.c.
Generally careless conditions throughout.....	398,000
Careless conditions except that cows were brushed daily, without however, removing possibility of contact with manure.....	316,500
Careless conditions, except that care was taken to remove manure from contact with cows, cows not brushed.....	69,200
Careless conditions, except that manure was removed and cows brushed daily.....	48,800
Care exercised by the milker as well.....	27,600
In addition, care given to the milking pail.....	3,200

The cows can be kept clean more readily if the hair on the udder, flanks and tail is kept short by clipping. Much less dirt will then cling to the coat of the animal.

To produce milk of the highest grade, it is recommended to wash off the udder and teats of the animal with a damp cloth just before milking, in order to remove dust, loose hairs, etc. Clear warm water may be used or a weak disinfectant solution such as a one-half per cent solution of Lysol or similar germicide. It is important to dry well, preferably with a second clean cloth, to remove all excess liquid which might otherwise drip into the pail. Compared with the practice of keeping the cow's coat well groomed and free from dirt, this wiping of the udder before milking is a factor of lesser importance. Only when the animal's coat is clean will the additional effort taken in wiping the udder be worth while. This is illustrated as follows:—

#### EFFECT OF WIPING UDDER BEFORE MILKING

	Bacteria in milk, per c.c.
Generally careless, unsanitary conditions.....	397,600
Same conditions only cow's udder wiped off just before milking.....	449,000
Same conditions but in addition to wiping off udder, cow's coat kept clean and free from contact with dirt.....	48,800

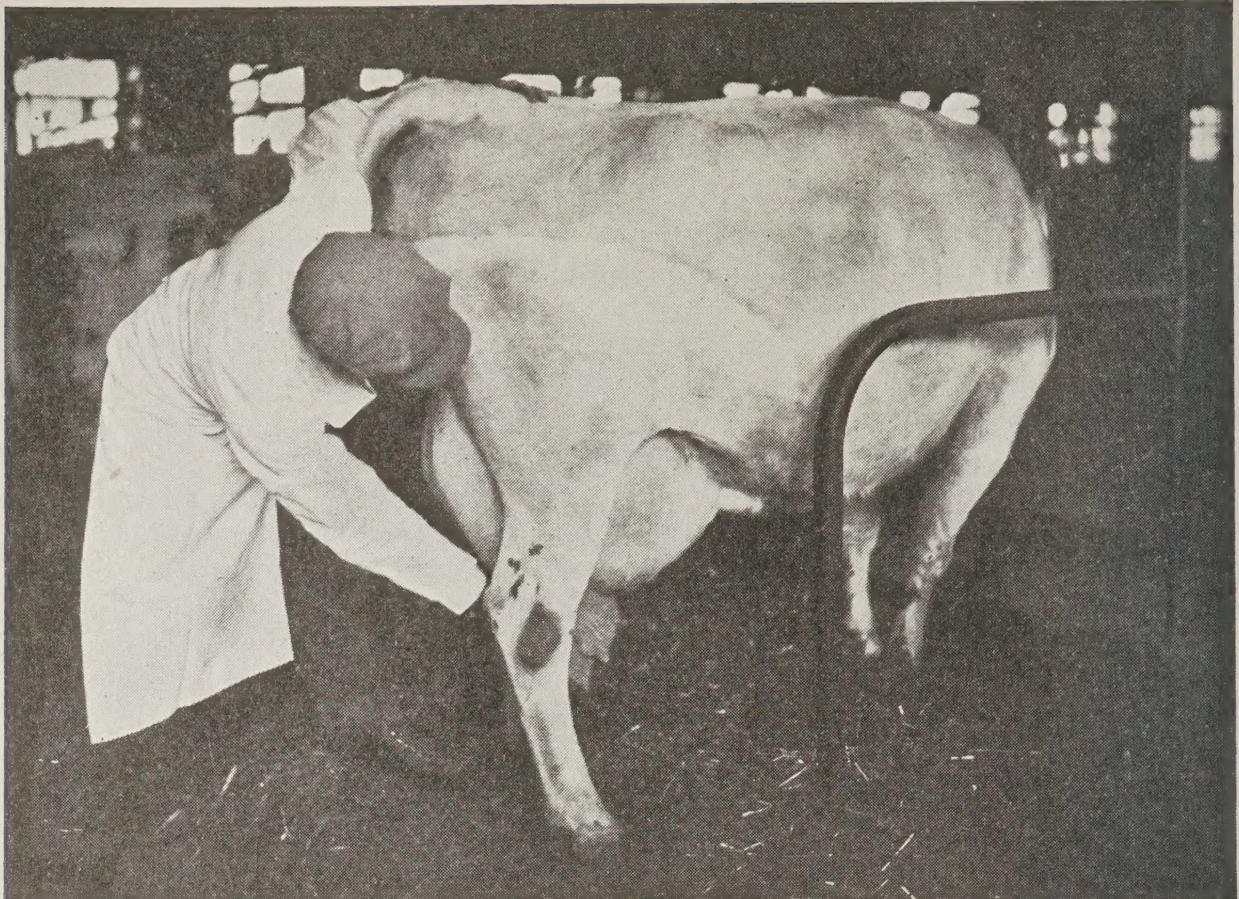


Fig. 3—Wiping off the udder just before milking with a clean damp cloth helps to keep the germ content of the milk down. This is essential for the best-grade milk; although only when the animal's coat is kept brushed and otherwise clean will this precaution be worth while.

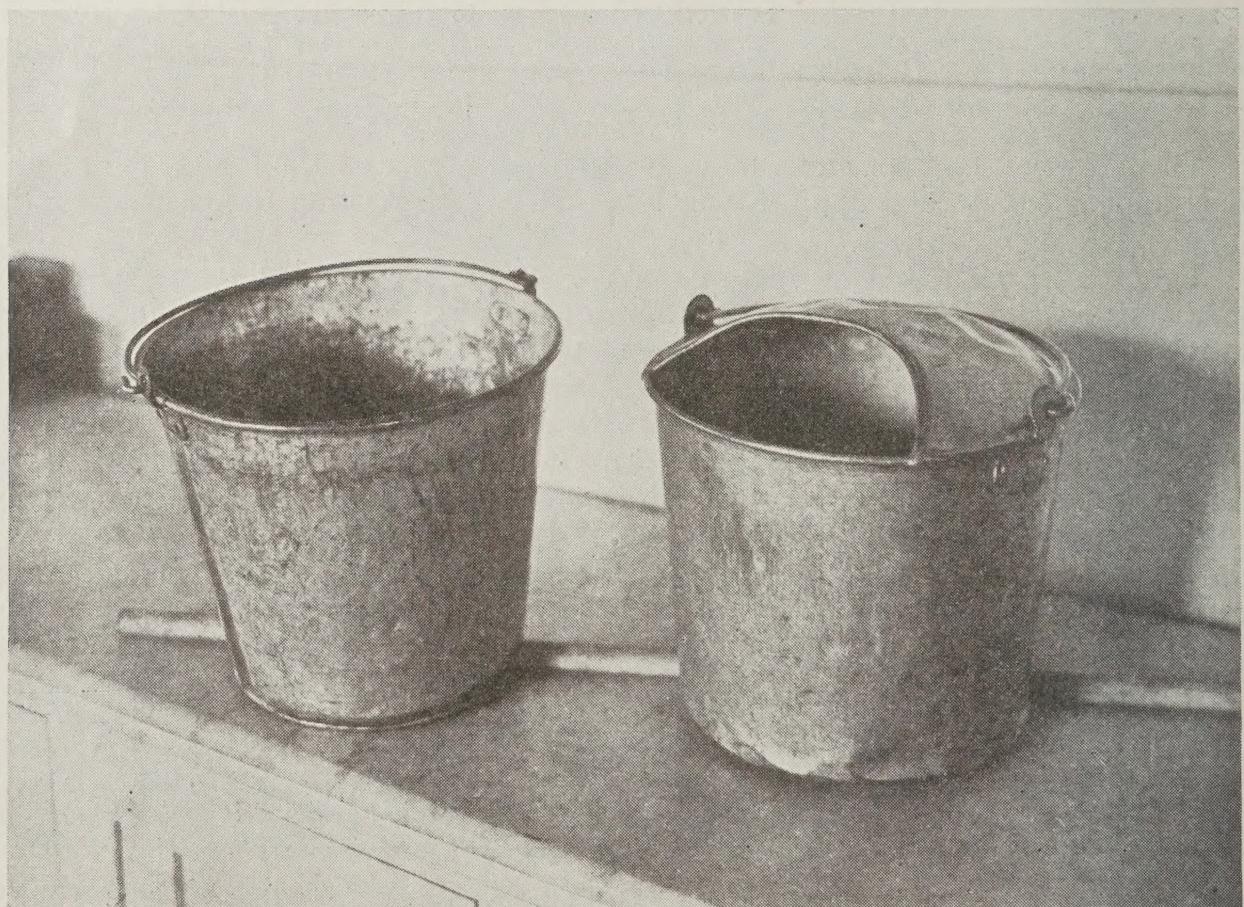


Fig. 4—The small-top pail, such as shown on the right, is one of the important factors in clean milk production. By the use of such a partly covered pail many bacteria are excluded which would fall into an uncovered pail (left) and contaminate the milk.

### SMALL-TOP PAILS

In helping to keep the contamination from the cow's body at a minimum, the use of a covered pail is to be strongly recommended. Even under good stable management there is an ever-present danger of accidental contamination from small particles of manure, dust, hairs, etc., which are inevitably dislodged at every milking, a contamination which can be markedly reduced by using a small-top pail. The extent to which a pail of this kind will keep out bacteria will naturally vary greatly depending upon the other conditions prevailing as the following table shows.

#### EFFECT OF USING SMALL-TOP PAIL

	Bacteria in milk, per c.c.		
	Open pail	Small-top pail	Decrease
Generally sanitary, careful methods.....	4,560	3,200	1,360
Pails clean, animals and stables clean, milker however careless.....	10,490	9,150	1,340
Pails clean, cows milked cleanly, stable clean, but animals not regularly cleaned.....	37,670	12,000	25,670
Generally careless conditions throughout.....	397,600	192,500	205,100

A producer really anxious to improve the quality of his milk should certainly employ the small-top pail. This must be regarded as an important factor in clean milk production, but as the figures show, it is not sufficient in itself. It can materially reduce, though by no means eliminate, contamination from a dirty cow and is to be used as an additional safeguard with, and not a substitute for, clean cows.

#### IMPORTANCE OF A CLEAN, STERILIZED PAIL

Together with dirt from the cow, the imperfectly cleaned milking-pail is the chief source of bacterial contamination of milk. What holds true of the milking-pail is the same with every other container with which the milk comes in contact, indeed the state of the utensils appears to be the most important single factor affecting the germ content of milk. Under clean milking conditions, a change from a careful method of cleaning the pails to a neglect in their proper care resulted in a greater increase in the germ content than the neglect of any other single precaution. This was shown as the result of a series of tests (see following) in which the effect of single careless operations in increasing the bacterial content of the milk was determined.

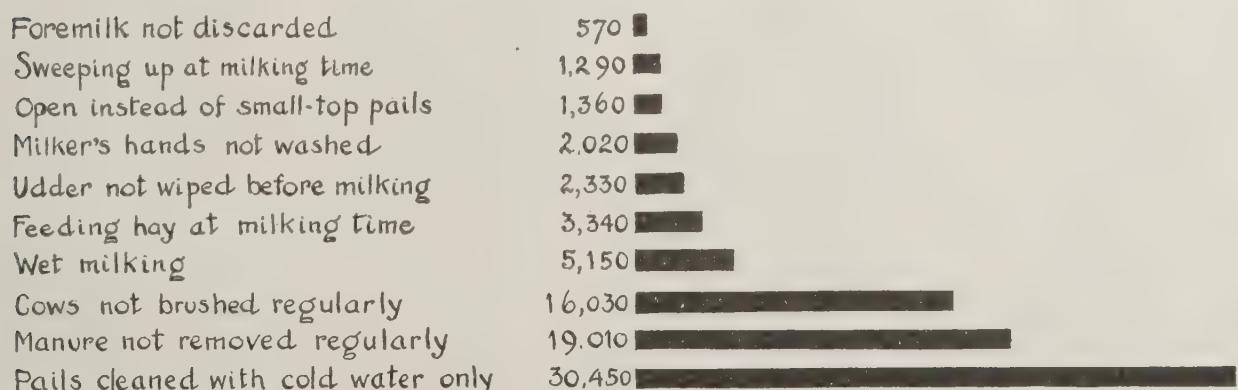


Fig. 5—Increase in germ content of milk due to various single factors. Apart from the factor in question, all other conditions as clean as possible.

It should be pointed out that all other operations, except the single one mentioned were performed in as sanitary a manner as possible. The pails causing the extra contamination noted were apparently clean, but were not bacteriologically clean, that is, were not sterilized. The production of milk with a low bacterial count is impossible unless the cleaning of pails, cans or other containers is followed by a sterilizing treatment, for a pail may be clean to the eye and yet contain huge numbers of living bacteria capable of infecting the fresh milk.

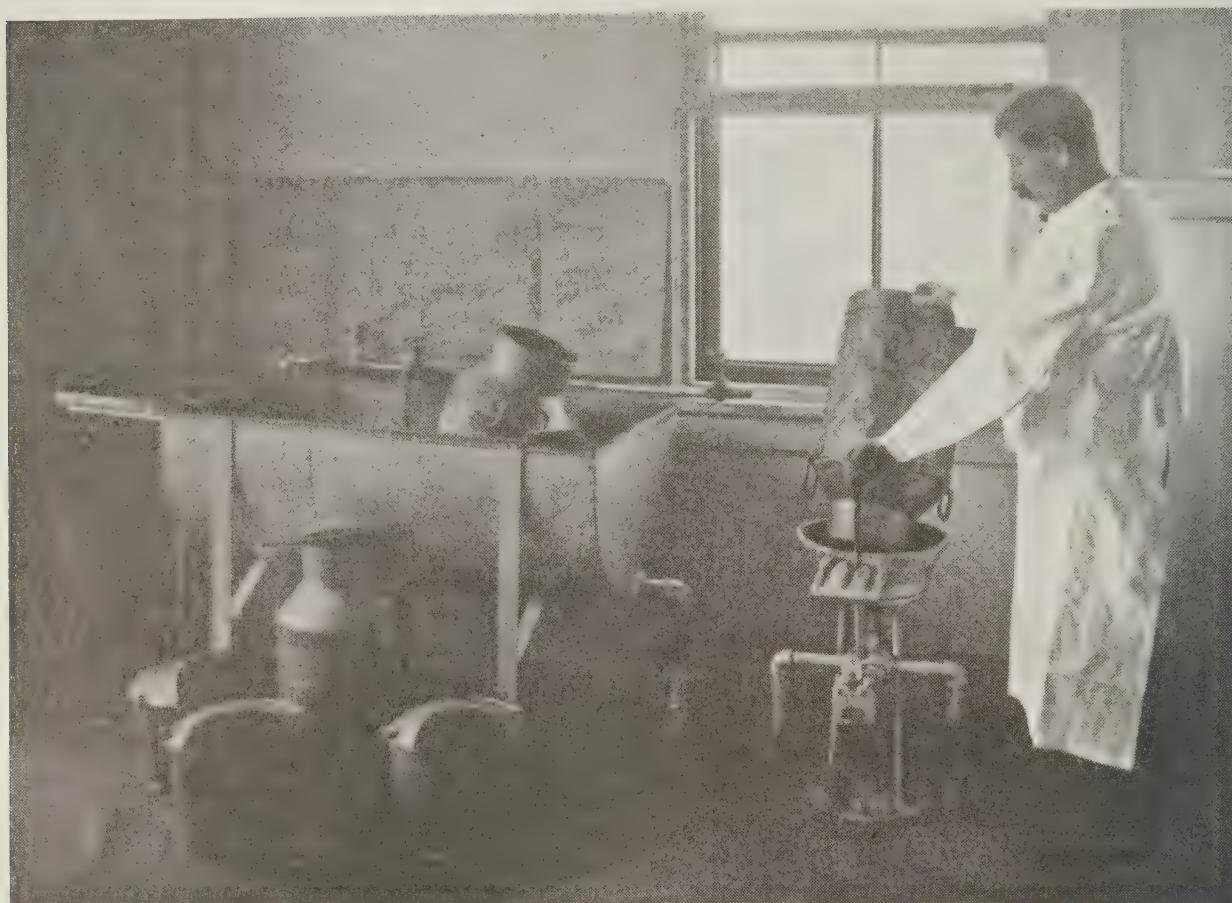


Fig. 6—The proper cleaning and sterilizing of all utensils is one of the foremost factors in producing milk with a low bacterial content. After a thorough washing, cans, pails, etc., should be sterilized by being subject to steam (in the illustration a jet of steam is used) or immersion in scalding water.

#### CLEANING AND STERILIZING PAILS AND OTHER UTENSILS

The proper treatment of milk utensils consists first, in rinsing in cold or luke-warm water immediately after using, before traces of milk have had a chance to dry on, and then washing well in warm water to which soda or a dairy cleansing powder has been added. For this operation a brush rather than a cloth should be used. After washing, the utensils should be rinsed in clean hot water to remove traces of the cleaning solution and finally sterilized.

Although the utensils may appear clean after washing they may still contain many thousands of germs which can easily be destroyed through sterilization by means of heat. Steam treatment, where this is available, is the most efficient means of sterilizing utensils and is best done by placing the utensils in a closed container into which steam can be blown for 15 minutes. Inverting the cans or pails over a steam jet for a couple of minutes is also a satisfactory method, though with this system there is often a tendency to remove the utensils before they have become properly sterilized. Steam should be allowed to act long enough to make the whole pail or can unbearably hot to the hand. Where

live steam is not available, the utensils may be immersed in scalding water for at least two minutes. After sterilizing the utensils should be allowed to dry thoroughly in some clean place where they can be kept inverted, free from dust until the next milking. A cloth should not be used to dry utensils, as it would only add germs. If pails are removed from the water or steam while still hot they will dry rapidly themselves.

If a bacteriologically clean milk is to be obtained a plentiful supply of boiling water or steam is a necessity. Although the preliminary cleaning assists in removing germs, yet it is in itself insufficient and must be followed up by a sterilizing treatment as the following figures show. Apart from the question of sterilizing the pails, the milk was obtained in a very careful sanitary manner.

#### EFFECT OF STERILIZING THE PAIL ON THE CLEANLINESS OF MILK

	Bacteria per c.c. milk (small-top pails used)
Pails cleaned with cold water.....	33,700
Pails rinsed with cold water and washed with hot water, but not sterilized.....	14,460
Pails sterilized after being washed.....	3,200

Utensils are much more difficult to clean if they are of complicated construction, offering many crevices in joints, seams, dints and cracks where traces of milk can lodge. Consequently the inside of the pails and cans should be as smooth as possible with well soldered seams, or of seamless construction, in order to facilitate cleaning and sterilization.

#### LESSER SOURCES OF CONTAMINATION

While a clean pail, a covered pail and a clean cow are the chief factors in clean milk production, yet there are other sources of contamination which help to add to the germ content of the milk. The careful producer, anxious to supply a pure food product, will wish to guard against what might be called lesser sources, as he must do if the best quality of milk is to be obtained.

**CONTAMINATION FROM THE COW'S UDDER.**—Bacteria are present in the udders of all cows, though the numbers vary naturally from animal to animal. Even in the best of circumstances one must reckon on a certain unavoidable contamination due to germs already in the milk when it passes out of the teat. Bacteria find their way to the udder through the teat opening. Although one must always count on some contamination in the milk leaving the teat, yet it may be lessened by keeping the udder clean and out of danger of contact with manure and by keeping the cows from wading in deep mud, etc. It was found, in the course of a series of tests, that the germ content of the milk coming directly from the teat could be reduced by adopting clean methods of handling the cows and caring for the stable. The following figures, representing samples taken at different periods of the milking, with special precautions to avoid all exterior contamination, are averages for twelve cows, and show how the udder contamination decreases with the adoption of clean methods.

#### EFFECT OF CLEAN METHODS IN THE STABLE ON UDDER CONTAMINATION

	Bacteria per c.c.		
	Foremilk	Middle milk	Last milk
Cows and stable neglected.....	26,450	5,880	9,250
Stable neglected, but cows brushed daily.....	13,720	2,430	3,130
Stable regularly cleaned, cows neglected.....	13,360	2,200	1,550
Cows brushed, stable clean.....	6,420	1,220	1,720

The foremilk is in all cases the most heavily laden with germs due no doubt to many germs becoming dislodged from the sides of the teat canal with the first few jets. The contamination from this source, however, when spread over the whole milking is usually very slight, and is to be regarded as a factor of very minor importance.

#### EFFECT OF DISCARDING THE FOREMILK ON THE BACTERIA CONTENT OF MILK

	Bacteria in Milk per c.c.	
	Sanitary conditions	Unsanitary conditions
Foremilk not discarded.....	3,770	397,600
Foremilk discarded.....	3,200	393,800

The practice of discarding the foremilk makes no appreciable difference under otherwise careless conditions, and it is only of value as an added precaution in obtaining the best quality of milk. With healthy cows, contamination from the udder is to be considered of minor importance as affecting the total germ content of the milk. In diseased conditions, however, the milk may contain enormous numbers of bacteria, such as those connected with garget or other udder infections; consequently when udder trouble is noticed, or when the milk of a cow appears ropy, slimy or watery or in any way abnormal, it should not be used.

**STABLE AIR AS A SOURCE OF CONTAMINATION.**—Fortunately contamination from the air of the stable is much less serious than is generally supposed. In every cow-stable the air is more or less dusty, the amount of the dust being noticeably increased by sweeping or by removing manure, and particularly by the handling of dry forage such as hay or straw. Particles of dust always carry with them bacteria, and by falling into an exposed pail of milk are able to add to the general contamination. It was found in a series of tests, however, that even when considerable dust is afloat in the atmosphere of the stable, the added contamination from this source is much less than might be supposed. While the actual number of germs falling into a pail might appear large, yet when distributed through the milk, the actual increase is small as the following figures show:—

#### CONTAMINATION FROM DUSTY STABLE AIR

	Bacteria falling per minute into a pail 11 inches in diameter	Contamination per c.c. milk (say 10 lb. in 8 minutes)
No sweeping or handling of hay one hour before milking	10,800	22
Feeding hay ten minutes before milking.....	23,300	45
Cleaning and sweeping ten minutes before milking.....	31,600	62

Contamination from dust is naturally greater if the air is disturbed while the milking is actually in progress. The average germ content of the milk, under generally careful conditions, 3,200 per c.c., was increased to 4,490 per c.c. when sweeping was done at the time of milking, and to 6,540 when hay was fed just at milking time. Naturally these are unnecessary sources of contamination, and although of secondary importance, should be guarded against by so arranging that no dust-creating operations are performed for at least 20 or 30 minutes before milking time. Moreover the use of a small-top pail, in addition to minimizing the more serious contamination from the cow, will aid in keeping at a low level the numbers of germs entering from the barn atmosphere.

**CONTAMINATION FROM THE MILKER.**—The milker himself may influence the germ content of the milk to an extent depending upon his personal cleanliness and upon the care he takes in handling the cow. Contamination due to the milker is not relatively large as far as bacterial numbers are concerned, but is important inasmuch as the milker may be a cause of spreading disease germs. Typhoid fever, scarlet fever and diphtheria are types of diseases which may be spread by milk. These are not animal diseases, and consequently the cow cannot be blamed, but the germs responsible are introduced into milk by careless handling on the part of people who are sick or carry the germs on their persons. Clearly, then, no person ill or recovering from an infectious disease should be allowed to milk cows or handle milk in any way. The milker should always milk with clean hands, and that this may be possible, facilities for the washing the hands, soap and clean towels should be available in every dairy. It can never be too strongly impressed upon all handling milk that they are dealing with a human food, which is very easily spoiled. For this reason the practice of wet milking is to be discouraged as being most unhygienic even though the actual bacterial contamination thereby is not great.

Under otherwise careful, sanitary conditions it was found that the adoption of wet milking in place of dry milking increased the germ content of the milk from 3,200 to an average of 8,800 per c.c. and failure to wash the hands from 3,200 to 5,200 per c.c. When wet milking was done with hands unwashed the average figures were 10,600 per c.c. These sources of contamination on the part of the milker are to be regarded as minor ones, yet if the very best quality of milk is to be got, they should be avoided as much as possible. Care in these matters, however, may be considered as wasted energy if contamination from the major sources, namely dirt from the animal and unclean utensils, is not prevented at the same time. The point is illustrated by the following figures:—

**SHOWING RELATIVE IMPORTANCE OF CLEAN HANDS AND CLEAN MILKING  
IN THE PRODUCTION OF CLEAN MILK.**

	Bacteria per c.c. Milk.
Generally careless, unsanitary conditions .....	397,600
"      " only the milkers' hands washed.....	388,900
"      " only dry milking instead of wet.....	490,000
In addition to clean milking, care taken with the cows.....	62,800
In addition to clean milking, care taken with the cows and the utensils.....	3,200

Washing the hands, and dry milking are in themselves of little value in cleaning up a milk supply but help to produce clean milk provided other improvements are also made.

#### THE PRODUCER IS THE CHIEF FACTOR

It should be clearly emphasized that the extent to which milk will be contaminated depends largely on the producer himself and the methods he employs rather than on the barn and dairy equipment he possesses. Other things being equal a modern well-ventilated, well-lighted barn with up-to-date fittings will be of advantage, but in itself, elaborate equipment is no guarantee of clean milk. It is possible to produce clean milk under the simplest conditions and with but comparatively crude equipment provided the producer has learned the sources from which the chief contamination comes, and is willing to take comparatively simple precautions to guard against them. On the other hand, even with the most modern and up-to-date facilities for producing clean milk, a producer may deliver grossly contaminated milk through careless methods of handling. When a producer, whatever his surroundings may be, makes a change from a careless

to a careful method of handling, the contamination may be almost entirely prevented by exercising ordinary sanitary precautions once he understands the source of bacterial contamination.

To produce the highest grade of milk, contamination from all sides must naturally be excluded as far as possible. Only when care is paid to stable, animals, utensils, and the method used by the milker can the cleanest milk be drawn.

A producer intent on cleaning up his milk supply can best commence by insuring that his pails are clean and scalded and that the chance of dirt falling from the cow into the pail is reduced to a minimum. While other sources of bacteria serve to add to the germ content of the milk, yet in comparison to the chief sources, namely badly cleaned pails and dirt from the cow, they are of minor importance and have undoubtedly been given too much emphasis in the past.

It should not be assumed that we advise neglecting these so-called minor sources. The point is simply this: *Care taken to prevent contamination from the minor sources is wasted unless at the same time contamination from the chief sources is also prevented.* Only when the pail is sterilized and the cow is clean will the extra precautions show results. Clean stable air, freshly white-washed walls, clean hands and coats, discarding the foremilk, etc., will be of little avail if the milker brings in a dirty pail or loosens a piece of manure from the cow's flank into the milk. A clean pail, a covered pail and a clean cow are the main factors in producing clean milk.

#### MAINTAINING CLEAN MILK

As a rule very little milk is consumed or used for manufacture immediately it is removed from the stable. While prompt disposal is to be aimed at, yet the great bulk of the milk must be kept for varying periods of time before it can be used. It follows, then, that one of the problems of the producer is to keep the germ content of his milk from increasing during this inevitable period of storage. This can be accomplished only by an efficient system of cooling. Bacteria have an enormous capacity for multiplying at ordinary temperature, and unless the milk is quickly cooled and kept cool until it is delivered, sanitary precautions taken in the stable may be offset through the rapid increase of the original contaminating germs.

Milk should be cooled as rapidly as possible after being drawn. This may be done best by the use of a milk-cooler in which the milk is allowed to flow in a thin layer over a metal surface which is kept cool with cold water; or by simply setting the milk cans promptly in a tank of ice-water. The temperature of properly cooled milk should not be over 50° F. To attain this temperature satisfactorily, it will be found that ice is usually required. With ordinary well-water the cooling is much slower and often will not be thorough enough, especially during the warm months. While the increase of bacteria in milk is comparatively slow at 50° F., yet at a temperature of 60° it is surprisingly rapid, so that after a day's storage at the higher temperature thousands will have become millions. For that reason ice is to be recommended as an important factor on every dairy farm in pure-milk production. When milk is cooled in cans, it is well to note that stirring greatly helps the milk to attain a low temperature.

Finally the producer should realize that every handling tends to increase the total germ content of the milk. Every container into which the milk is poured adds its quota of germs depending on the care exercised in cleaning and sterilizing. Unnecessary handling, then, is to be avoided, and the same careful attention should be given to sterilize all containers as has been recommended for the milking-pails. Only by keeping milk cool in clean containers can the original contamination be kept at a low level.